Crop Profile for Rutabaga in Canada, 2018

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Preface

National crop profiles are developed by the Pest Management Program of Agriculture and Agri-Food Canada (AAFC). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

Information on pest issues and management practices is provided for information purposes only. For detailed information on growing rutabaga, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile. For guidance about crop protection products registered for pests on rutabaga, the reader is referred to provincial crop production guides and Health Canada's Pesticide label database.

Every effort has been made to ensure that the information in this publication is complete and accurate. Agriculture and Agri-Food Canada does not assume liability for errors, omissions, or representations, expressed or implied, contained in any written or oral communication associated with this publication. Errors brought to the attention of the authors will be corrected in subsequent updates.

Agriculture and Agri-Food Canada gratefully acknowledges the contributions of provincial crop specialists, industry specialists and growers in the gathering of information for this publication.

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The rutabaga (*Brassica napus* var. *napobrassica*), also known as "swedes", is a member of the Brassicaceae family. The plant is a cross between turnip (*Brassica rapa*) and cabbage (*Brassica oleracea*) and originated in Scandinavia or Russia in the 17th century. Rutabaga was introduced into North America by European immigrants in the early 19th century. The rutabaga root consists of both a true root and true stem. The upper portion of the stem forms a neck, which distinguishes rutabaga from turnip. The rutabaga is a biennial plant, requiring two years to complete its entire life cycle, from seed to seed. However, only one growing season is required for the production of the edible root, which is the commercial product.

Crop Production

Industry Overview

The root of the rutabaga is used as a vegetable for human consumption and historically has been used for animal feed. Rutabaga stores well and is available year-round. Rutabaga greens like turnip greens can be used for salads and other mixes. Rutabaga is relatively low in calories and is a good source of vitamins A and C, potassium, folate and fibre. A summary of Canadian rutabaga production information including export and import data is presented in Table 1.

Table 1. General rutabaga production information in 2018

Canadian production[2]	**Rutabagas**[1]
	47,138 metric tonnes 1,530 hectares
Farm gate value[2]	$28.9 million
Fresh rutabaga available in Canada[3]	1.17 kg/person
Exports[4]	1,650 metric tonnes
Imports[4]	2,000 metric tonnes

[1]Including fresh rutabagas and turnips
[2]Statistics Canada. Table 32-10-0365-01 - Area, production and farm gate value of vegetables, 2018 data (accessed: 2020-07-07)
[3]Statistics Canada. Table 32-10-0054-01 - Food available in Canada, 2018 data (accessed 2020-07-07)
[4]Statistics Canada. Table 32-10-0053-01 - Supply and disposition of food in Canada, 2017 data (accessed 2020-07-07)

Production Regions

Rutabaga is grown commercially in a number of provinces in Canada. However, the majority of production is located in Ontario (43%), Quebec (29%) and Prince Edward Island (11%) (Table 2). British Columbia, Alberta, Nova Scotia, and Newfoundland and Labrador produce small acreages (about 4% each).

Table 2. Distribution of production by province, 2018

Production Regions	Area planted[1] (hectares) and percentage	Farm gate value[1] ($)
	Rutabagas[2]	
British Columbia	61 ha (4%)	$2.0 Million
Alberta	61 ha (4%)	$1.3 Million
Ontario	658 ha (43%)	$11.8 Million
Quebec	435 ha (29%)	$8.9 Million
Nova Scotia	66 ha (4%)	$0.9 Million
Prince Edward Island	155 ha (11%)	x
Newfoundland and Labrador	65 ha (4%)	$1.5 Million
Canada	1,530 ha	$28.9 Million

[1]Statistics Canada. Table 32-10-0365-01 - Area, production and farm gate value of vegetables (database accessed 2020-07-07).
[2]Including fresh rutabaga and turnip
[X]Suppressed to meet the confidentiality requirements of the Statistics Act

Cultural Practices

While there are over a dozen varieties of rutabaga available in Canada, almost all commercially seeded rutabaga is the *Laurentian* variety. The *York* variety is used for transplant rutabaga. Other varieties grown in Canada include *American Purple Top*, *Marian*, *Fortin*, and *Joan*.

Rutabaga grows best on moderately acidic, well-drained clay loam soil with good tilth and organic matter. Soils that have good drainage are essential for fall or winter harvest. The

crop will also grow well on moderately acid loams and sandy loams. On sandy loams, roots tend to elongate, especially in dry weather or with high plant populations. Rutabaga is rarely grown in sandy soils because the coarse sand grains can be abrasive and cause injury to the root tissues. Wounded roots do not keep well during long-term storage. Soil crusting can be a problem on heavy soils in fields with poor rotation (i.e., a rotation which does not provide sufficient organic matter) because the crust can prevent the cotyledons from breaking through the soil surface.

A crop rotation of four to seven years out of Brassica crops is used by growers in order to obtain acceptable reductions in insect pest and disease pressures. Brassicaceae weeds are controlled during this time, as they can serve as hosts for many insects and diseases that attack rutabaga. Planting rutabaga following cereal crop plough down (stubble) instead of sod from perennial legumes such as alfalfa or clover will reduce the potential for the development of diseases and damage from pests that thrive in sod (e.g. wireworms and slugs). Limited nitrogen is required for rutabaga growth, and this is easier to manage following stubble than following a legume crop that fixes nitrogen. Using legumes in the rotation for two or more years will improve the soil structure and is beneficial, as long as the rutabaga crop does not immediately follow the legume crop.

Rutabaga is typically planted in rotation following crops in which weeds can be thoroughly controlled since herbicides recommended for use on rutabaga do not provide total weed control.

Soil tests to determine fertilizer requirements and soil pH are carried out before seeding, and adjustments are made to ensure a limited supply of nitrogen, for slow and steady growth of a well-formed root, and to achieve a soil pH range of 6.0 to 6.8. Other major nutrients applied may include phosphorus, boron, magnesium and gypsum (sulphur).

Rutabaga is directly seeded in the field or grown from transplants in some provinces. Seeding can begin as soon as the soil can be worked in the spring. Rutabaga that is intended for storage is planted in early to mid-June, allowing the plants to develop later in the season during the cool fall weather. Early-seeded crops may not be suitable for fall harvest and storage as they can develop woody roots and have poor quality. The optimum soil temperature for germination is 16 to 19 ºC; however, seeds can germinate in soil temperatures as low as 5 ºC. A fine smooth seedbed is required for uniform seeding depth. Seeding is done at a rate of 225 to 500 g/ha and depth of 0.6 to 1.5 cm. Seeds are spaced 10 to 15 cm apart in rows that are spaced 50 to 90 cm. Spacing affects the harvest date and the root size. Wide in-row spacing is used for early production and close spacing is used for producing smaller roots. Precision seeders are used to space seeds at accurate intervals producing a uniform crop and eliminating the need for thinning. Thinning, if required, is normally done when plants are 4 to 8 cm high.

Transplants can be used for early-market rutabaga production. Transplants are started in late March and set in the field in late April. Plastic row covers or floating row covers can be used to increase early growth after transplants are set out. Maturity of most rutabaga varieties range between 90 and 95 days; some varieties can reach maturity between 40 and 60 days.

Rutabaga is well adapted to cool and humid growing conditions, with optimal temperatures for growth between 15 and 20 ºC. Although frost tolerant, the plants are not usually left in the ground later than the end of October. Harvesting is done only when roots are fully mature and have been exposed to frost events before harvest, as this promotes best quality and flavour. Immature roots have a bitter taste and, if early-seeded rutabaga are left in the field until

late fall, the roots tend to become fibrous and woody. Optimal storage conditions include air temperatures around 0 ºC and relative humidity greater than 95 percent. A wax coating is applied to rutabaga to enhance their appearance and to prevent dehydration.

Table 3. General rutabaga production and pest management schedule in Canada

Time of Year	Activity	Action
March	Plant care	Transplants started from seed in late March
April	Plant care	Transplants set in the field in late April
May	Plant care	Planting of crops destined for early season markets
	Soil care	Fertilization and pH adjustments (liming) before planting, based on soil tests; application of required phosphorous, potassium and boron
	Disease management	Seed treated with fungicides in some provinces
	Insect and mite management	Monitoring; treatment against cabbage maggot, if necessary
	Weed management	Soil cultivation, mechanical weeding and pre-emergence pesticide treatments, if necessary
June	Plant care	Planting of crops (early-mid June, later in some areas) intended for storage
		Monitoring and irrigation, if used
	Soil care	Topdressing with organic matter in some regions
	Disease management	Monitoring and fungicide treatment, if necessary
	Insect and mite management	Monitoring and insecticide treatment, if necessary; installation of insect netting
	Weed management	Post-emergent herbicide treatment and mechanical weeding, if necessary
July	Plant care	Monitoring and irrigation, if used
	Soil care	Limited activities
	Disease management	Monitoring and fungicide treatment, if necessary
	Insect and mite management	Monitoring and insecticide treatment, if necessary
	Weed management	Limited activities; mechanical weeding in some regions
August	Plant care	Monitoring and irrigation (if used); early harvest
	Soil care	Limited activities
	Disease management	Monitoring and fungicide treatment, if necessary
	Insect and mite management	Monitoring and insecticide treatment, if necessary
	Weed management	Limited activities
September/ October	Plant care	Harvest and storage
	Soil care	Cultivation

Abiotic Factors Limiting Production

Herbicide Sensitivity

Rutabaga is extremely sensitive to spray drift of phenoxy herbicides from nearby applications, such as for field crop weed control. Seedling crops of rutabaga may show little, if any, visible signs of phenoxy herbicide damage. However, trace or even undetected levels of phenoxy herbicide residue can result in an unmarketable crop. Rutabaga is also sensitive to herbicide carryover from previous crops. In particular, herbicides containing the active ingredient metribuzin (used on potato and soybean, among other crops) applied the year before planting rutabaga in the same field can pose a very strong risk of crop injury.

Brown Heart

Brown heart (also known as water-core) is a disorder of the rutabaga root that occurs when there is a deficiency in boron availability. Affected roots have brown, discoloured areas that may appear soft and water-soaked. The discolouration varies from light to dark brown, and can occur as a single area or several smaller areas scattered throughout the centre of the root. By the time brown heart develops, it is usually too late to correct with boron applications. Rutabaga grown in soils containing less than 0.5 ppm soluble boron are more likely to develop brown heart. As well, plants grown under dry conditions or when the soil pH is higher than 7.0 may not absorb boron efficiently. The cultivar *York* tends to be less susceptible to brown heart than *Laurentian (Thompson* strain).

Temperature Extremes and Low Light

Rutabaga is a biennial plant. It forms a swollen root during the first year and flowering stems in the second year of growth, after a cold period. The exposure of very early-seeded plants or transplants to temperatures below 5 ^{o}C, when they are less than ten weeks old, can trigger the development of flowering stems. The exposure of plants to temperatures around 3 ^{o}C for as little as three to five nights is thought to result in the development of flowering stems. However, the duration of the low temperature period that triggers flowering will vary depending on the variety being grown.

Greenhouse transplants grown under low light conditions and subjected to large temperature differences between day and night may also suffer from misshapen roots (long cylindrical shapes). The establishment of good ventilation during bright and sunny days and/or providing supplementary heating during cool nights will minimize these temperature differences within the greenhouse.

Prior to harvest, rutabaga can tolerate a limited period of temperatures as low as –3 ^{o}C; however, if a significant frost occurs over a prolonged period (longer than 24 hours), the root may freeze, develop a glazed appearance and be unsuitable for storage or sale.

Water / Moisture Stress

Rutabaga can withstand dry periods with minimal soil moisture, but will have a slower growth rate under these conditions. Excess water also reduces growth. Cracking of the root may occur with a fast growth rate due to excessive fertilization, wide spacing and hot humid weather. Cracks act as potential entry sites for soft rot bacteria.

Harvesting in warm or wet conditions, or putting wet roots into storage can reduce storage quality by making the crop more susceptible to post-harvest diseases. Roots harvested during dry weather tend to shrivel and soften if the level of humidity is not sufficient in storage. Optimal storage conditions include air temperatures around 0 ^{o}C and relative humidity greater than 95 percent. A wax coating can be applied to rutabaga to prevent dehydration in storage.

Bruising / Mechanical Damage

Rutabaga is very susceptible to bruising, which can lead to the development of rot in storage. Bruising may not be apparent until the crop has been stored for three to four months. Harvesting can be done by hand or mechanically. Mechanical harvesting can cause bruising to the roots, and this requires producers to take extra care to minimize injury, especially for roots intended for long-term storage. Rutabaga lends itself well to extended cold storage for up to nine months over the winter and spring periods.

Diseases

Key Issues

- There is a need for the registration of new fungicides for the management of a number of diseases of rutabaga, including clubroot, Rhizoctonia diseases and downy mildew, and for resistance management.

Table 4. Occurrence of diseases in rutabaga production in Canada[1,2]

Disease	Ontario	Quebec	Prince Edward Island
Blackleg			
Black rot			
Grey leaf spot (Alternaria leaf spot)			
Downy mildew			
Powdery mildew			
Clubroot			
Common scab			
Rhizoctonia diseases			
Root rot			
Sclerotinia rot (white mold)			
Soft rot/ neck rot			
Turnip Mosaic Virus			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest is present and of concern, however little is known of its distribution, frequency and pressure.			
Pest not present.			
Data not reported.			

[1]Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island); the data reflect the 2018, 2017 and 2016 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 5. Adoption of disease management practices in rutabaga production in Canada[1]

Practice / Pest		Clubroot	Root rot / Crater rot / Wirestem	Downy mildew	Powdery mildew	Black rot
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth and to minimize stress					
	Minimizing wounding and insect damage to limit infection sites					
	Use of disease-free propagative materials (seed, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds, etc.)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infected material throughout the growing season					

… continued

Table 5. Adoption of disease management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Clubroot	Root rot / Crater rot / Wirestem	Downy mildew	Powdery mildew	Black rot
Prevention	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity					
Monitoring	Scouting / spore trapping					
	Maintaining records to track diseases					
	Soil analysis for the presence of pathogens					
	Weather monitoring for disease forecasting					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed disease symptoms					
	Use of portable electronic devices in the field to access pathogen / disease identification / management information					
Suppression	Use of diverse product modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pathogen populations					

… continued

Table 5. Adoption of disease management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Clubroot	Root rot / Crater rot / Wirestem	Downy mildew	Powdery mildew	Black rot
Suppression	Use of biopesticides (microbial and non-conventional pesticides)					
	Controlled atmosphere storage					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					
Crop specific practices	Hilling of soil along plants					

This practice is used to manage this pest by at least some growers in the province.

This practice is not used by growers in the province to manage this pest.

This practice is not applicable for the management of this pest

Information regarding the practice for this pest is unknown.

[1]Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island); the data reflect the 2019, 2018 and 2017 production years.

Blackleg (*Phoma lingam*, sexual stage: *Leptosphaeria maculans*)

Pest Information

Damage: This disease can reduce vegetable and seed crop yields. Low levels of seed infection, coupled with weather favourable for disease spread in seedbeds, can lead to severe losses after transplanting by damping-off. Early symptoms of blackleg appear as small pale and irregular spots on leaves of young plants. The spots become roundish or oval and ashy grey in colour. On stems, the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fibrous root system may be destroyed, although new roots formed above the lesion may keep the plant alive. Plants can be stunted and may exhibit wilting during warm, sunny days. Eventually, plants may collapse from stem rot or fall over from poor root anchorage. During rainy weather, secondary diseases are common on plants infected with blackleg and may mask blackleg infections. Mechanical, insect or herbicide injury can result in greater disease severity.

Life Cycle: Phoma lingam is a destructive fungal pathogen that is often spread on seed. The fungus can survive for years in association with seed. It overwinters on plant debris and on alternate host plants and can survive up to four years on decomposing plant debris. The fungus infects a range of brassica crops and weeds and is especially prominent in canola. The disease can spread by splashing rain or irrigation water, workers, contaminated equipment and by ascospores that can be carried several kilometres by wind. The pathogen has the potential to spread very rapidly through a field.

Pest Management

Cultural Controls: Weed control in ditches and hedgerows around the field may help to minimize infection in the field. Delaying spring planting until fields are drier can reduce spread of disease, as can adjusting plant spacing to enable good air flow between plants. Disease incidence can be reduced by avoiding planting rutabaga adjacent to or downwind from fields that were cropped to brassica crops or canola in the previous year or adjacent to or downwind from fields that were infected within the last three to four years. Rotation out of brassica crops for four to five years, avoiding use of manure from animals which have consumed infected plants, and removal of brassica weeds are all common practices used to minimise the risk of blackleg infection. The use of certified disease-free seeds) also helps limit the incidence of the disease.

Resistant Cultivars: None available.

Issues for Blackleg

None identified.

Black Rot (*Xanthomonas campestris* pv. *campestris*)

Pest Information

Damage: Black rot is considered the most important bacterial disease of brassica crops worldwide. Infected leaf tissue develops V-shaped, yellow lesions at the leaf margins and chlorosis can progress toward the leaf center. Veins in these areas become dark brown or black. As the infection becomes systemic, symptoms may appear anywhere on the plant and stunting occurs. Blackened vascular tissues may develop in roots.

Life Cycle: The bacterial pathogen can overwinter in plant debris for up to two years and be carried internally within the plant and externally on seed. The bacterium infects a range of brassica crops and weeds. It may be spread in the field by wind, water, insects, equipment, humans and animals. Free water from dew, rain or irrigation is necessary for spread. The pathogen enters water pores at leaf margins or through mechanical injuries. Many outbreaks can be attributed to disease spread in the seedbed, and infected seed is the main source of black rot. A seed lot with as few as five infected seeds per 10,000 (0.05%) can cause a high incidence of black rot in the field.

Pest Management

Cultural Controls: Controlling brassicaceae weeds and minimizing work in wet fields can help to minimize the spread of disease. A four-year rotation can minimize pathogen presence. A reduction in seeding rates and planting densities that promote good air circulation can also help reduce the development of black rot. It is good practice to clean and disinfect equipment used in an infected field before it is used in other fields. The use of certified, disease-free seed will minimize the risk of introducing the black rot pathogen to the field. The removal and destruction of diseased plants from the field will help to limit the spread of the disease. Additional management practices for black rot are listed in Table 5.

Resistant Cultivars: None available.

Issues for Black Rot

1. There is a need for the registration of bactericides for the control of black rot.

Grey Leaf Spot (Alternaria Leaf Spot) (*Alternaria brassicae*)

Pest Information

Damage: Alternaria diseases can affect many brassica crops. Grey leaf spot starts as small brown or grey lesions that enlarge overtime, changing to spore covered brown spots

Life Cycle: Alternaria brassicae survives between seasons as spores on the seed, as mycelium in seed, in infected plant debris and on brassica weeds. Field infections may arise from seed-borne inoculum as well as wind-blown spores produced in infected crop debris and weeds.

Extended periods of leaf wetness favour infection. Spores produced in leaf lesions are disseminated by wind, water and tools throughout the growing season.

Pest Management

Cultural Controls: Seed treatments will destroy *Alternaria brassicae* carried in or on seeds. In the field, infections can be reduced with plant spacing that facilitates air movement and drying of the plants. Long crop rotations, field sanitation and weed control will reduce inoculum build-up and disease carry-over.

Resistant cultivars: None available.

Issues for Grey Leaf Spot

None identified.

Downy Mildew (*Peronospora parasitica*)

Pest Information

Damage: Symptoms of downy mildew include distinct, angular yellow areas on the upper surface of leaves and fluffy, white patches of mycelial growth on the lower surface. Rutabaga roots can be invaded systemically, resulting in internal darkening of the root and in advanced cases, cracks or splitting of the root.

Life Cycle: The disease is favoured by cool moist weather and is a problem on rutabaga in the spring and fall. Temperatures in the range of 10 to 15 ^{o}C and free moisture on the leaves are optimal for spore production and initiation of new infections. Spores are spread by wind and splashing rain. The fungus overwinters on seed, in brassicaceae weed hosts and likely in soil.

Pest Management

Cultural Controls: Keeping transplant seedlings and leaves as dry as possible will help in minimizing the presence of the disease. A minimum three-year crop rotation using grains and grasses will contribute to breaking the infection cycle. Plowing under crop residue following harvest in infected fields can speed its decomposition and reduce disease carry-over to the next season. Proper spacing to allow airflow is also important to minimize disease progression. Fertilization may help seedlings outgrow infection. Additional management practices for downy mildew are listed in Table 5.

Resistant Cultivars: None available.

Issues for Downy Mildew

1. The registration of new classes of fungicides to be used in rotation for resistance management is required for downy mildew control.

Powdery Mildew (*Erysiphe polygoni*)

Pest Information

Damage: Powdery mildew appears as a white, powdery fungal growth on the upper surfaces of leaves which can eventually grow to cover the entire leaf surface and spread to lower leaf surfaces. In advanced stages, leaves turn yellow and die and prematurely drop. This may result in reduced growth and yields and make mechanical harvesting of the crop difficult.

Life Cycle: Erysiphe polygoni is a fungal pathogen that occurs in several physiologic races and attacks a wide range of plants. The fungus is spread by wind-blown spores. The fungus overwinters on brassica plant debris, weeds and seeds. The disease is more severe under conditions of low relative humidity and water stress within the plant.

Pest Management

Cultural Controls: Maintaining sufficient spacing between plants will reduce disease incidence and severity. Plowing under crop residue following harvest in infected fields can speed the breakdown of infected plant material, reducing disease carry-over to the next season. Isolation of rutabaga fields from other brassica crops, and rotations away from brassica crops are also appropriate methods to reduce the incidence of powdery mildew. Additional management practices for powdery mildew are listed in Table 5.

Resistant Cultivars: None available.

Issues for Powdery Mildew

None identified.

Clubroot *(Plasmodiophora brassicae)*

Pest Information

Damage: Diseased plants become chlorotic, are slow to grow and develop, and may partially wilt during warm days. Large, spherical, club-like growths develop below the enlarged area of the root, which become infected with secondary bacteria, resulting in rot. Infected rutabaga roots are unmarketable.

Life Cycle: The fungus survives in the soil as resting spores for seven years or longer after a diseased crop. The presence of certain weeds of the brassica family, such as wild radish and wild mustard will maintain or increase the disease inoculum in the soil year after year. Soils that are cool, wet and acidic (pH less than 7.2) favour the disease. The fungus is soil-borne and is spread by infected seedlings, contaminated manure, water, wind, farm equipment, animals, and footwear. It invades roots through wounds and root hairs and causes swelling and distortion. Motile spores are released from infected roots and swim in moisture films to other roots.

Pest Management

Cultural Controls: Maintaining a rotation of at least seven years out of brassica crops, and being vigilant in scouting for disease in the crop can help to reduce incidence and severity of clubroot. Planting in fields with a known history of clubroot and use of manure from animals fed clubroot infected crops are avoided to reduce the risk of disease. Careful adherence to field and machinery sanitation to minimize the potential movement of the pathogen from field to field will help to contain clubroot problems. Planting of infested land to a sod crop, such as hay or pasture, for at least seven years, to prevent the movement of soil can help to prevent the spread of the pathogen from infected fields. Additional management practices for clubroot are listed in Table 5.

Resistant Cultivars: Kingston, *Laurentian*, *Marian*, *York* and *Joan* are resistant to some races of clubroot.

Issues for Clubroot

1. There is a need for the registration of pesticides for the management of clubroot.
2. There is a need for the development of new varieties of rutabaga with resistance to individual and multiple races of clubroot.

Common scab (*Streptomyces scabies*)

Pest Information

Damage: Streptomyces scabies causes scab on rutabaga and other root and tuber crops. Scab lesions result in corky tissue that is usually darker than healthy tissue. Lesions can appear sunken or raised above surrounding healthy tissue. Scab lesions do not continue to develop in storage but can reduce the marketability of the rutabaga crop.

Life Cycle: The pathogen survives in plant residues in the soil and can be carried in manure from animals fed with infected crops. The pathogen can be spread by splashing rain and windblown soil. Scab develops most rapidly at soil temperatures of 20 to 22 °C. Scab is more severe in light, sandy soils. The disease is favoured by alkaline soil conditions and is more severe in soils with pH above 5.2.

Pest Management

Cultural Controls: To reduce the likelihood of scab development, excess applications of lime which could lead to alkaline soil conditions should be avoided. Manure from animals fed on scab-infected tubers and roots should not be applied to fields intended for planting of rutabaga, and short rotations between susceptible crops, including potatoes, sugar beets, carrots and brassica crops are avoided.

Resistant Cultivars: Rutabaga cultivars such as Norking, Superior, Cherokee, and Huron have good resistance to common scab.

Issues for Common Scab

None identified.

Rhizoctonia diseases: Root Rot (Crater Rot), Wirestem (*Rhizoctonia solani*)

Pest Information

Damage: Rhizoctonia solani causes damping-off, wirestem and root rots of rutabaga, turnip and other brassica crops. Seeds may rot before germination or seedlings may die and fail to emerge from the soil. Stem infections on small, young plants may result in a dark decay and sloughing off of the outer cortex, a symptom commonly called wirestem. On mature roots, root rot lesions (crater rot) may be sunken, spongy and brown with purplish rims that may develop into large irregular black craters with a scabby appearance.

Life Cycle: The pathogen is soil-borne and survives the winter as mycelium or sclerotia in soil and plant residues. Infection occurs through wounds and directly through the cuticle. Slow growing seedlings are more susceptible to disease. Field infections may be more severe when the control of root maggot is not adequate. Soil contamination of storage bins can increase the spread and severity of disease in storage.

Pest Management

Cultural Controls: Avoidance of deep planting and planting into excessively cold or wet soils may reduce disease rates. Adequate air movement between plants and rotation with grass or cereal green manure crops can also reduce the severity of this disease. As infections can be initiated in storage after harvest, regular clean up and sterilization of tools and storage bins are considered to be good practice. Additional management practices for rhizoctonia diseases are listed in Table 5.

Resistant Cultivars: None available.

Issues for Rhizoctonia Diseases

1. There is a need for the registration of additional fungicides for the management of rhizoctonia diseases and for resistance management.

Root Rot (*Fusarium* spp. and *Pythium* spp.)

Pest Information

Damage: Root rot diseases affect the root system and the lower portion of the stem at the soil line. Infected plants may be yellowed and stunted. Root rotting pathogens cause seed decay and seedling blight and infected seedlings often die. Plants affected by fusarium root rot have reddish-brown lesions on the below-ground stem and root systems. Plants severely affected

will produce numerous adventitious roots. This disease is favoured by compacted soil or low soil fertility. Typical symptoms of Pythium root rot include decay on seed, seedlings and roots leading to premature death of the plant (damping-off).

Life Cycle: These pathogens overwinter in soil and crop debris. They respond to plant root exudates and invade plant roots. Cool, wet weather in the spring may favour root rot development. Water stress later in the season contributes to symptom development. More specifically, Fusarium overwinters in soil as chlamydospores (asexual resting spores which are resistant to extreme temperature and moisture, and germinate after a period of dormancy). The pathogen can disseminate through dust on seed, wind or water-borne soil. *Pythium* species are common in soil and can persist for many years as oospores (diploid fungal resting spores). They have a wide host range and are favoured by high soil moisture.

Pest Management

Cultural Controls: Seeding at proper depths into warm, slightly moist, well-drained soil will favour emergence of the crop and reduce problems due to root rot. Crop rotations that exclude brassica crops will help reduce pathogen populations in the soil. Minimizing soil compaction and using cover crops may also favour soil structure, organic matter and drainage. Avoiding green manure immediately before planting may also reduce root rots.

Resistant Cultivars: None available

Issues for Root Rot

None identified.

Sclerotinia Rot (white mold) (*Sclerotinia sclerotiorum*)

Pest Information

Damage: Sclerotinia sclerotiorum has a broad host range and can attack many crops. . In rutabaga, it is primarily a storage rot, where the disease can spread rapidly from infected rutabaga to healthy ones. Fluffy white mycelium and black resting structures (sclerotia) develop in infected tissues.

Life Cycle: Sclerotinia sclerotiorum can survive in infected plant debris and persist in the soil for many years in the form of hard-bodied sclerotia (masses of fungal mycelium in a resting stage) that are produced in infected tissues. Sclerotia in soil germinate when exposed to adequate soil moisture and moderate temperatures (11 to 15 °C). Germination of sclerotia produces mycelium or apothecia which release ascospores into the air. The ascospores are carried by wind to host plants where they can infect leaves, stems and roots. Mycelium infects near-by susceptible tissues.

Pest Management

Cultural Controls: Growing non-susceptible crops in close proximity to rutabaga fields and ensuring a three to five-year crop rotation, will reduce disease incidence. Seeding into well

drained soil, effective weed control and the removal and destruction of infected plant material may also help reduce the spread of this disease. Improving aeration at the soil surface by increasing row spacing to reduce humidity within the canopy will also reduce the risk of disease development. To minimize disease spread in storage, roots are rapidly cooled after harvest and only healthy, undamaged roots are stored.

Issues for Sclerotinia Rot

None identified.

Soft Rot / Neck Rot (*Pseudomonas* spp.)

Pest Information

Damage: The tops of affected plants appear weak or are easily pulled from the root. Root tissues become soft, rotted and smelly with the exterior of the root remaining intact.

Life Cycle: Soft rot bacteria are present in soil, rotten vegetables and on host plants. They are introduced into rutabaga through wounds caused by insect feeding, dry rot, physiological injuries such as growth cracks, or mechanical injury. High temperatures and soil moisture favour soft rot. Severe injury to foliage caused by powdery mildew may also predispose the neck tissues to soft rot. The disease can spread rapidly in storage.

Pest Management

Cultural Controls: The management of soft rot is dependent on preventative measures including the use of cultural practices and strict sanitation measures. Cultural practices such as following a four to five-year rotation with non-brassica crops and non-host crops will help prevent infections in rutabaga. To prevent disease spread in storage, only healthy, undamaged roots are stored and storage containers are cleaned thoroughly and disinfected prior to use.

Resistant Cultivars: None available.

Issues for Soft Rot / Neck Rot

None identified.

Turnip Mosaic Virus (TuMV)

Pest Information

Damage: Turnip mosaic virus causes premature yellowing and loss of older leaves on affected rutabaga plants, resulting in a “goose-necked” appearance. Younger foliage may become

distorted and mottled. Early season infections result in reduced size of the roots. The loss of leaves makes mechanical harvesting difficult.

Life Cycle: The virus overwinters in living tissues including winter canola crops, some brassicaceae weeds, volunteer rutabaga plants and infected rutabaga roots from storage warehouses that are discarded in early spring. The virus is transmitted by aphids and is not seed borne.

Pest Management

Cultural Controls: Avoiding planting rutabaga near fields of winter canola will reduce the potential for disease spread into the rutabaga crop. Early planting will enable the growth of the crop before populations of the aphid vectors become high. The removal of volunteer rutabaga and culls from storage, as well as the isolation between late seeded fields and early seeded fields, will help prevent the spread of the virus.

Resistant Cultivars: None available.

Issues for Turnip Mosaic Virus

None identified.

Insects and Mites

Key Issues

- There is a need for the registration of new insecticides to control many insect pests of rutabaga.
- There is a critical need for the registration of insecticides outside of groups 1B and 28 for the management of cabbage maggot and for resistance management.
- There is an urgent need for the development of alternative, cost effective management strategies for cabbage maggot in rutabaga.

Table 6. Occurrence of insect pests in rutabaga production in Canada[1,2]

Insect and mite	Ontario	Quebec	Prince Edward Island
Cabbage (root) maggot and other root maggots			
Wireworm			
Swede midge			
Aphids			
Cabbage aphid			
Green peach aphid			
Turnip aphid			
Cabbage looper			
Diamondback moth			
Imported cabbage worm			
Cutworms			
Black cutworm			
Variegated cutworm			
Red turnip beetle			
Flea beetles			
Crucifer flea beetle			
Striped flea beetle			

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and pressure.

Pest not present.

Data not reported.

[1]Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island); the data reflect the 2018, 2017 and 2016 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 7. Adoption of insect pest management practices in rutabaga production in Canada[1]

Practice / Pest		Aphids	Cabbage maggots	Flea beetles	Diamondback moth	Imported cabbageworm
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth					
	Minimizing wounding to reduce attractiveness to pests					
	Reducing pest populations at field perimeters					
	Use of physical barriers (eg. mulches, netting, floating row covers)					
	Use of pest-free propagative materials (seeds, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to manage plant growth					
	Management of soil moisture (improvements to drainage, use of raised beds, hilling, mounds, etc.)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infested material throughout the growing season					
	Tillage / cultivation to expose soil insect pests					
	Removal of other hosts (weeds / wild plants / volunteer crops) in field and vicinity					

… continued

Table 7. Adoption of insect pest management practices in rutabaga production in Canada1 (continued)

Practice / Pest		Aphids	Cabbage maggots	Flea beetles	Diamondback moth	Imported cabbageworm
Monitoring	Scouting / trapping					
	Maintaining records to track pests					
	Soil analysis for pests					
	Weather monitoring for degree day modelling					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of pest at susceptible stage of life cycle					
	Use of portable electronic devices in the field to access pest identification / management information					
Suppression	Use of diverse pesticide modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations					
	Use of biopesticides (microbial and non-conventional pesticides)					
	Release of arthropod biological control agents					
	Preservation or development of habitat to conserve or augment natural controls (e.g. preserve natural areas and hedgerows, adjust crop swathing height, etc.)					

… continued

Table 7. Adoption of insect pest management practices in rutabaga production in Canada1 (continued)

Practice / Pest		Aphids	Cabbage maggots	Flea beetles	Diamondback moth	Imported cabbageworm
Suppression	Mating disruption through the use of pheromones					
	Mating disruption throught the release of sterile insects					
	Trapping					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					
Crop specific Practices	Use of exclusion fencing					
	Use of row covers (mesh net)					
This practice is used to manage this pest by at least some growers in the province.						
This practice is not used by growers in the province to manage this pest.						
This practice is not applicable for the management of this pest						
Information regarding the practice for this pest is unknown.						

[1]Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island); the data reflect the 2019, 2018 and 2017 production years.

Cabbage Maggot (*Delia radicum* and other *Delia* spp.)

Pest Information

Damage: This insect is the most serious pest of rutabaga in Canada. Larvae or maggots feed by tunnelling into the roots. Plants may be killed, weakened or stunted and yields reduced. Severely infected plants wilt and remain in place in the row, unlike those severed at ground level by cutworms. A small amount of tunnelling in rutabaga roots renders the crop unmarketable.

Life Cycle: There are two to three generations of cabbage maggot per year. Pupae overwinter in the soil near the roots of the host plant. Adult flies emerge in the spring and lay oval shaped, white eggs at the base of the stem of host plants or in nearby crevices in the soil. Eggs hatch in three to seven days, and the larvae feed on host plants.

Pest Management

Cultural Controls: Many brassica crops act as a host for cabbage maggot, therefore planting rutabaga crops away from other brassica crops may help to keep pest pressure down. Crop rotation with non-host crops can help to break the pest cycle. Floating row covers can provide a physical barrier to help prevent egg laying and damage. The Reduced-Risk Strategy for Cabbage Maggot in Brassica Crops (see Reference Section) includes information on netting technologies evaluated in different Canadian growing regions. Many naturally occurring beneficial insects and nematodes can help reduce populations of cabbage maggot. In Newfoundland and Labrador, it was found that the beetle, *Aleochara bilineata*, can kill large numbers of cabbage maggot pupae and can feed on eggs. Additional information about cultural management of this pest is available in in Table 7.

Resistant Cultivars: PMC funded a project to evaluate cabbage maggot-resistant rutabaga lines (AAFC PRR10-140). The three most promising lines were commercialized and are currently undergoing commercial field testing.

Issues for Cabbage Maggot

1. There is a need for the development of a cost effective, integrated approach to the management of cabbage maggot in rutabaga.
2. There is a critical need for the registration of insecticides, including those outside of groups 1B and 28, for the management of cabbage maggot. There are currently no effective controls for this insect.

Wireworms (Various species)

Pest Information

Damage: The larvae feed on roots and seed in the soil. Plants attacked during emergence or soon after transplanting are often killed. Damage occurring close to harvest can reduce the

marketability of the crop and may also pre-dispose rutabaga roots to secondary bacterial infections.

Life Cycle: Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The eggs hatch in about a week and depending on the species, larvae will live for three to five years in the ground feeding on roots and seeds. Wireworms require three or more years to complete their life cycle. Wireworms of all sizes and ages are present in the soil throughout the year as there is always an overlapping of generations. Mature larvae pupate in the fall and emerge in the spring as adult beetles. Wireworms are often numerous in soils that have been in sod for several years; however, they are becoming an increasing problem in fields that have been in cultivation for a number of years. They are also more abundant in heavy, poorly drained soil.

Pest Management

Cultural Controls: Avoiding planting into fields known to be infested or which were recently in sod, as well as eliminating grassy weeds within fields during the growing season will help minimize wireworm infestation as grasses are known hosts for egg-laying females. Rotation with non-host crops and intensive plowing, three or more times during the late spring and early summer can also reduce wireworm populations. Bait stations set out in the spring or in the fall provide a method for monitoring wireworm presence. Trap cropping with wheat or applying a trap and kill strategy may provide some protection from damage to the rutabaga crop. A National Wireworm Species Distribution Map is available to identify infestation zones in Canada (see Reference Section).

Resistant Cultivars: None available.

Issues for Wireworm

1. Improved control strategies, including cultural and biological approaches, are required for wireworm as there are no effective controls.
2. There is a need for the registration of products that will control wireworm in rutabaga.

Swede Midge (*Contarinia nasturtii*)

Pest Information

Damage: Swede midge, native to Europe and Asia is a serious pest of brassica crops. In North America, the first detection was in Ontario in 2000. Since that time established populations of swede midge have been detected in Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia and Prince Edward Island, and in the eastern U.S. Damage is the direct result of larval feeding. Larvae produce a secretion that breaks down the plant cell wall, allowing them to feed on the liquid contents. Larval feeding changes the physiology of the plant and results in the formation of swollen, distorted and twisted tissue, including leaf stalks. Roots become deformed and loose their marketable value.

Life Cycle: Swede midge overwinters in the larval stage in cocoons in the soil. First-generation adults emerge in the spring from mid-May until mid-June and mate soon after. Females lay two to 50 eggs in clusters on the youngest, actively growing vegetative tissue, commonly near the

growing point during her lifetime (1 to 4 days). After hatching, the larvae begin feeding. Depending on climatic conditions there can be up to five generations per year. Swede midge adults may be present until early October and larvae may be found on plants until mid-October. Pre-pupae of the last generation go into diapause, overwintering in cocoons in the soil and pupate the following spring.

Pest Management

Cultural Controls: Crop rotation is the most effective way to reduce swede midge populations. With multiple generations per year, swede midge populations can build up very quickly under continuous production of a host crop. Swede midge may survive in the soil for two or more years; therefore, a crop rotation that does not include brassica crops is essential. Pheromone traps are commercially available to monitor adults and help time treatments. Traps must be checked frequently due to the short generation time of the midge. Planting only early-season brassica crops is another control strategy to reduce damage levels and population growth. If fields are planted prior to adult emergence in early June, damage will be less severe than in later plantings. Avoiding late-season crops will also help reduce the size of the overwintering swede midge population in a field.

Resistant Cultivars: None available.

Issues for Swede Midge

None identified.

Aphids: Cabbage Aphid (*Brevicoryne brassicae*), Green Peach Aphid (*Myzus persicae*) and Turnip Aphid (*Lipaphis erysimi*)

Pest Information

Damage: Aphids feed by sucking plant sap. Saliva injected while feeding may introduce plant viruses (e.g., turnip mosaic virus) or may be toxic to the host plant. Feeding by large numbers of aphids causes foliar discolouration, leaf curling and damage to developing buds. A sticky substance, called honeydew, is excreted by feeding aphids and may cover the leaves and crown and result in sooty mould growth.

Life Cycle: In late spring, aphids move from their overwintering hosts to crop plants. At this time, populations consist primarily of females that can reproduce without mating and bear live young. At certain times of the year male aphids arise, mating occurs and eggs are produced. Low populations of some species can quickly increase during warm, dry weather and completely colonize the upper parts of the plant. The turnip aphid is very prolific and can live 20 to 40 days, producing 80 to 100 young during their lifetime.

Pest Management

Cultural Controls: Separating plantings of early and late rutabaga crops and growing rutabaga crops at a distance from corn fields, may reduce the aphid population moving into a rutabaga crop.

Naturally occurring predators including ladybird beetles and parasitoid wasps may suppress aphid numbers, particularly later in the season. Additional management practices for aphids are listed in Table 7.

Resistant Cultivars: None available.

Issues for Aphids

None identified.

Cabbage Looper (*Trichoplusia ni*)

Pest Information

Damage: The larval stage of the cabbage looper feeds voraciously on the underside of leaves resulting in ragged-edged holes between plant veins. Severely infested plants become stunted and may die.

Life Cycle: Since the cabbage looper prefers warmer climates, it is only a serious pest in southern regions of Canada where the pest can have as many as three generations per season, as compared to just one generation in the Atlantic Provinces. This insect does not overwinter in Canada; every spring it migrates as an adult moth from the southern United States, arriving in Canada in July or August. Eggs are mostly laid on the underside of large leaves located higher on the plant, close to the edge of the foliage. Following larval feeding, pupation occurs in webbed cocoons (chrysalis) attached to the stems or undersides of leaves. It takes approximately one month of warm weather for the cabbage looper to complete its life cycle.

Pest Management

Cultural Controls: Many brassica crops act as a host for cabbage looper, therefore planting rutabaga crops away from other brassica crops may help to keep pest pressure down. Cabbage looper is susceptible to numerous entomopathogens, including fungi, protozoa, bacteria and viruses. Natural enemies such as parasitic wasps and tachinid flies may also contribute to population suppression. Predators include ground beetles, lady beetles, bugs, spiders, birds and small mammals

Resistant Cultivars: None available.

Issues for Cabbage Looper

None identified.

Diamondback Moth (*Plutella xylostella*)

Pest Information

Damage: Diamondback moth larvae feed on the leaves of rutabaga. While early instars mine into the leaves, older larvae feed on the undersides of leaves, eating out small irregular holes. Severely damaged leaves may develop a silvery appearance and crowns may occasionally be damaged.

Life Cycle: In most years, this insect does not overwinter in Canada and new infestations result from moths that are blown northward from the United States in the spring. Larvae of the first-generation feed on brassicaceae weeds prior to moving into planted crops. Eggs are laid on the foliage of host crops. When feeding is complete, the larvae spin cocoons and pupate on the host crop. This insect can have three to six generations per year. Hot and dry conditions can cause a population outbreak and moths can appear suddenly at epidemic levels, especially if cabbage fields are nearby. Under cold and wet conditions this pest does not pose a problem.

Pest Management

Cultural Controls: Many brassicaceae crops act as a host for diamondback moth, therefore planting rutabaga crops away from other brassicaceae crops may help to keep pest pressure down. Crop rotation away from host crops and the elimination of weeds which act as alternate hosts will also minimize pest populations. Floating row covers can provide a physical barrier in small crop plantings to help prevent egg laying and damage. Inter-row planting with unrelated plants may provide benefits by attracting beneficial predatory insects and parasitic wasps, thereby decreasing the larval population. The diamondback moth is preyed upon by several species of wasps, including *Diadegma insulare* and *Microplitis plutaellae*, other insects, mites, spiders, and birds. Predicting the presence of larvae can be aided by monitoring for presence of the adults using pheromone baited traps. Deep ploughing of field debris late in the season reduces numbers of potentially over-wintering adults. Additional management practices for diamondback moth are listed in Table 7.

Resistant Cultivars: None available.

Issues for Diamondback Moth

1. Resistance to registered products is a concern as the diamondback moth has the ability to quickly develop resistance to pesticides. There is a need for the registration of additional control products with new chemistries as resistance management tools for diamondback moth.
2. Late season damage caused by the diamondback moth is increasing in Prince Edward Island and is of concern given the poor efficacy of currently available control products.

Imported Cabbageworm (*Pieris rapae*)

Pest Information

Damage: Larvae cause injury by chewing large irregular holes in the rutabaga leaves and staining the foliage with pellets of dark-green excrement. If left unchecked, the imported cabbageworm can completely defoliate the plant.

Life Cycle: Eggs laid singly on the underside of leaves give rise to velvety-green larvae. Larvae feed on foliage and when feeding is complete (two to three weeks), they pupate on the plant or plant debris. Various stages or instars may be seen on the foliage at the same time. There are two to three generations a year. Pupae over-winter on crop debris.

Pest Management

Cultural Controls: Many brassicaceae crops act as a host for imported cabbageworm, therefore planting rutabaga crops away from other brassicaceae crops may help to keep pest pressure down. Crop rotation, eliminating brassicaceae weeds, and planting the crop as far away from fields planted to brassica crops in previous years helps to reduce pest pressure. There are a number of wasps and flies that prey on the imported cabbageworm and some natural control may be contributed by these species. Floating row covers can provide a physical barrier to help prevent egg laying by the imported cabbageworm in small crop plantings. Additional management practices for imported cabbageworm are listed in Table 7.

Resistant Cultivars: None available.

Issues for Imported Cabbageworm

None identified.

Cutworms (Noctuidae): Black Cutworm (*Agrotis ipsilon*) and Variegated Cutworm (*Peridroma saucia*)

Pest Information

Damage: Black and variegated cutworms may cause considerable damage to rutabaga. They attack newly emerged young plants. Later, they also feed on the crown, burrowing into the root leaving deeps scars. Damage may occur in the spring and also later in the growing season. Late season infestations are difficult to detect and often are not noticed until harvest time.

Life Cycle: Cutworms pass through egg, larval, pupal, and adult stages and depending on the species, can have one or more generations per year. The spring generation is the most damaging because its occurrence coincides with seed germination. Although it has been generally thought that both of these species of cutworms were wind-blown northward from the U.S. as moths, there is mounting evidence that the variegated cutworm can overwinter as pupae in warmer parts of Canada.

Pest Management

Cultural Controls: Avoiding fields recently converted from meadowlands and those with large weed populations will reduce the risks of cutworm infestation. A thorough harrowing may provide adequate control when cutworms are feeding actively in established fields and fall tillage can help destroy overwintering pupae. Pheromone baited traps can be used to forecast the presence of larvae. Many natural predators, parasites and birds prey upon cutworms and reduce the population as do some nematode species. Both the granulovirus and the nuclear polyhedrosis virus have been shown to affect the variegated cutworm.

Resistant Cultivars: None available.

Issues for Cutworms

1. There is a critical need for the registration of insecticides for the management of cutworms to replace organophosphate insecticides and for resistance management.

Red Turnip Beetle (*Entomoscelis americana*)

Pest Information

Damage: Adults and larvae feed on leaves and stems of young plants. Damage is greatest in June when newly emerged adults migrate from infested fields of nearby brassica crops and weeds. Arrival of large numbers of beetles can lead to significant crop destruction.

Life Cycle: Eggs of the red turnip beetle are laid singly or in small clusters in the fall. Larvae hatch after snow melt in the spring, develop and then enter the soil to pupate, with adults emerging in June. Adults feed and then burrow into the soil, reappearing in late July and August when they mate and lay eggs to overwinter. There is one generation per year.

Pest Management

Cultural Controls: Fall or spring cultivation effectively reduces red turnip beetle eggs, larvae and pupae. The process of cultivation after harvest buries eggs, preventing larvae from emerging from the soil. Spring cultivation causes mechanical injury and/or desiccation of pupae. As well as the removal of host plants (e.g., brassica weeds), which limits food sources for developing larvae.

Resistant Cultivars: None available.

Issues for Red Turnip Beetle

None identified.

Crucifer Flea Beetle (*Phyllotreta cruciferae*) and Striped Flea Beetle (*Phyllotreta striolata*)

Pest Information

Damage: Adult beetles feed on cotyledons and young leaves of emerging seedlings creating small "shot holes". Heavy feeding will kill seedlings and if extensive in the field, may result in the crop having to be re-seeded. Flea beetle larvae feed on the root causing scarring of the root surface. Flea beetles are prevalent mostly in the spring and will attack most brassica crops.

Life Cycle: The pest overwinters as adult beetles in leaf litter of hedgerows and headlands around fields. Adults feed on brassicaceae weeds and volunteer crops until the host crop emerges. There is generally one generation per year. Adult beetles thrive in hot sunny weather and damage is most severe during such periods. The adult beetles lay eggs in soil near the roots of host plants and larvae feed on plant roots. Pupation occurs in the soil. Emergence of the next generation of adults begins in July. Adults feed on brassica crops at that time and seek overwintering sites in the fall.

Pest Management

Cultural Controls: Many brassica crops are hosts for crucifer flea beetle, therefore planting rutabaga away from other brassica crops may help to keep pest pressure down. Later plantings to avoid early season emergence and use of high seeding rates can reduce the impact of flea beetles on rutabaga. Floating row covers, sealed at the edges, can be used to exclude beetles during seedling establishment. As well, trap cropping (e.g., radish, daikon) around the perimeter of the field can be used to intercept beetles as they enter the field. Irrigation can be used during warm periods to drown adults. Additional management practices for flea beetles are listed in Table 7.

Resistant Cultivars: The variety *American Purple Top* has some resistance against flea beetles.

Issues for Flea Beetles

1. There is a need for the registration of new classes of insecticides for use against adult crucifer flea beetles, particularly at the first stages of crop growth. As well, there is a need for the registration of control products that target flea beetle larvae, which primarily cause root damage.

Weeds

Key Issues

- There is a need for the registration of new pre-plant and post-emergence products to control annual weeds in rutabaga, including related weeds in the brassica family.

Table 8. Occurrence of weeds in rutabaga production in Canada[1,2]

Weeds	Ontario	Quebec	Prince Edward Island
Annual broadleaf weeds			
Annual grasses			
Perennial broadleaf weeds			
Perennial grasses			
Cruciferous weeds			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest is present and of concern, however little is known of its distribution, frequency and pressure.			
Pest not present.			
Data not reported.			

[1]Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island); the data reflect the 2018, 2017 and 2016 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 9. Adoption of weed management practices in rutabaga production in Canada[1]

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	Cruciferous weeds
Avoidance	Varietal selection / use of competitive varieties					
	Planting / harvest date adjustment					
	Crop rotation					
	Choice of planting site					
	Optimizing fertilization for balanced crop growth					
	Use of weed-free propagative materials (seed, cuttings or transplants)					
	No till or low disturbance seeding to minimize weed seed germination					
	Use of physical barriers (e.g. mulches)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to maximize crop growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)					
	Weed management in non-crop lands					
Monitoring	Scouting / field inspection					
	Maintaining records of weed incidence including herbicide resistant weeds					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds					

…continued

Table 9. Adoption of weed management practices in rutabaga production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	Cruciferous weeds
Decision making tools	Economic threshold					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of weed at susceptible stage of development					
	Decision to treat based on observed crop damage					
	Use of portable electronic devices in the field to access weed identification / management information					
Suppression	Use of diverse herbicide modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations					
	Use of biopesticides (microbial and non-conventional pesticides)					
	Release of arthropod biological control agents					
	Mechanical weed control (cultivation / tillage)					
	Manual weed control (hand pulling, hoeing, flaming)					
	Use of stale seedbed approach					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms					

This practice is used to manage this pest by at least some growers in the province.

This practice is not used by growers in the province to manage this pest.

This practice is not applicable for the management of this pest

Information regarding the practice for this pest is unknown.

[1]Source: Rutabaga stakeholders in reporting provinces (Ontario, Quebec and Prince Edward Island); the data reflect the 2019, 2018 and 2017 production years.

Annual Grass and Broadleaf Weeds

Pest Information

Damage: Broadleaf weeds can compete with the crop for light, water and nutrients. If not controlled, they will reduce rutabaga growth and yield. Annual grasses have fast growth and the ability to compete for necessary resources, making them a serious problem. Grass weeds are very tolerant to extremes in moisture and temperature once established. They can be very difficult to eliminate from infested fields and they require management/ control prior to seed-set. In rutabaga production, the critical stage for control of annual weeds is early in the growing season.

Life Cycle: Annual grass and broadleaf weeds complete their life cycles in one year, going from seed germination through growth to new seed production. Spring annuals germinate in the early spring and produce seed in the summer or fall of the same year. Winter annuals begin their growth in the fall, growing a rosette and producing their seed early the following year. Annual weeds are very adept at disseminating through the production of large numbers of seeds. Most arable land is infested with annual weed seeds at all times and some weed seeds can remain viable in the soil for many years, germinating when conditions are favourable.

Pest Management

Cultural Controls: Managing weeds along road sides, ditches, and fence lines by mowing or planting perennial grasses can reduce these sources of infestations. Planting in a site that is as weed free as possible will allow rutabaga plants to thrive. Fields can be scouted the season before planting to determine which weeds might be expected and if these can be controlled in the rutabaga crop. The purchase of certified seed will also help reduce the seeding of weed seeds. The transport of weeds and weed seeds by equipment, soil and debris can be minimized by carefully cleaning equipment when leaving each field. Manure applications may also introduce weeds to a field. Repeated tilling prior to planting, and cultivation after planting will reduce germinating weeds. Monitoring for annual weeds can be done during the first two to three weeks after weed emergence if post emergence controls are to be applied. Row spacing that favours row closure will help prevent weeds from emerging. Rotating between broadleaf and grassy crops provides a chance to control broadleaf weeds in grassy crops and grassy weeds in broadleaf crops with selective herbicides. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimize erosion and nutrient loss over the winter. Information about the use of cover crops is available for eastern Canada (see reference). Additional management practices for annual grass, broadleaf weeds, and brassicaceae weeds are listed in Table 9.

Resistant Cultivars: Rutabaga varieties with quick emergence and vigorous crop stands will help shade out germinating weed seeds.

Issues for Annual Weeds

1. There is a need for the registration of new pre-plant and post-emergence herbicides to control annual weeds in rutabaga, including related weeds in the crucifer family.

Biennial and Perennial Weeds

Pest Information

Damage: Perennial weeds can become very large and be very competitive, especially if they have been established for several years.

Life Cycle: Biennial weeds germinate in the spring producing a rosette of leaves and remain vegetative during the first summer. They overwinter as rosettes and then during the second summer send up a flower stock on which seeds are produced. The original plants then die at the end of the second growing season. Perennial weeds can live for many years. They generally establish themselves from various types of root systems, although many will also spread by seed. Most perennial weed seeds germinate in the spring and the plants grow throughout the summer. During this period, the plants expand their root systems, sending up new plants along the roots, as well as expanding the size of existing plants. Tillage practices can break up the underground root systems and aid in the spread of perennial weeds. The critical stage for damage is early in the growing season, as for the other groups of weeds.

Pest Management

Cultural Controls: Cultivation is less effective at controlling perennial weeds due to their large root systems. Crop rotation can disrupt perennial and biennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Additional management practices for biennials and perennial weeds, are listed in Table 9.

Resistant Cultivars: Rutabaga varieties with quick emergence and produce vigorous crop stands will help shade out germinating weed seeds and compete better against developing weeds.

Issues for Perennial Weeds

1. There is a need for the registration of a longer acting, pre-plant or pre-emergence herbicide to keep the weed population under control when row covers are used and that can efficiently penetrate the “mesh” (row cover).

Resources

Integrated Pest Management and Integrated Crop Management Resources for Production of Rutabaga in Canada

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Provincial Contacts

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Dennis Van Dyk dennis.vandyk@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	Melissa Gagnon melissa.gagnon@ mapaq.gouv.qc.ca	Mathieu Coté mathieu.cote@ mapaq.gouv.qc.ca
Prince Edward Island	Prince Edward Island Department of Agriculture and Fisheries https://www.princeedwardisland.ca/en/topic/agriculture-and-fisheries	Adam MacLean adammaclean@gov.pe.ca	Sebastian Ibarra sibarra@gov.pe.ca

National and Provincial Vegetable Grower Organizations

Association des producteurs maraîchers du Québec: https://apmquebec.com/

Canadian Federation of Agriculture: https://www.cfa-fca.ca/

Canadian Horticultural Council: http://www.hortcouncil.ca

Canadian Organic Growers: https://www.cog.ca/

Ontario Fruit and Vegetable Growers Association: http://www.ofvga.org

Prince Edward Island Horticultural Association: https://www.peifarmcentre.com/tenants.php

Appendix 1

Definition of terms and colour coding for pest occurrence table of the crop profiles.

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 6 and 8 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and pressure in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="10">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="4">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="4">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="2">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td rowspan="2">Localized - as above</td><td>Low - see above</td><td>White</td></tr>
<tr><td>High - see above</td><td>Yellow</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="2">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="2">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>Blue</td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>Black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>Grey</td></tr>
</table>

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